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Data Requirements for Energy Planning in Developing Countries

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1. INTRODUCTION:

This paper deals with data needed for effective energy planning. Based on a study of the existing energy data systems in India and a number of other developing countries, the gaps and deficiences in these systems are identified and ways recommended to overcome them. These issues were discussed during the International Workshop on National Energy Data Systems held at New Delhi between December 12th and 14th, 1982. For the most part, these discussions have provided the background material for this paper.

The overall aim of energy planning can be defined as the development of the national energy supply and distribution network at the least social cost and in consonance with the objectives in other domains of planning. Like all planning activities, it is an important part of planning and has become more so in the last decade. Some of these are:

* Energy use pervades all sectors of the economy. One of the necessary conditions for the growth and development of any sector, is the assured availability of adequate energy supplies.

* Huge investments are involved in the energy sector - anywhere from a fifth to a third of the development budgets of many developing countries are devoted to energy related projects.

* Long lead time is involved between the time decisions are taken to build energy supplying units and the time these installations become operational.

* The long economic life of energy installations once they are constructed.

* The cost of errors in both directions - either of overcapacity or underutilizatiόn are very high. This has become even more pronounced because of escalations in energy costs during the last ten years.

* To ensure continued energy supplies in the event of disruption in any one source of supply.

The oil embargo of 1973 impressed upon the countries the dangers of excessively relying on any one source of supply, and diversification of supplies and

energy-mixes became household words. The emphasis in this paper is on energy importing developing countries. So for reasons of security and for finding cheaper alternatives to costly imported oil, energy substitution became an objective of energy planning. This, as we shall see later, requires that certain kind of data on existing energy use patterns in the country be collected.

Energy Planning, as we understand it, is an iterative process consisting of models based on data, yielding forecasts which determine policies which in turn lead to actions which generate more data. The sequential and unceasing nature of energy planning is shown schematically in Figure 1. This figure also indicates the influence of the other sectoral data and policies. The spatial and temporal perspectives of energy planning are delineated.

Traditionally, management of fuel supplies and distribution, partly because of their preoccupation with the 'present', have been activities separated from energy planning. We have intentionally shown, in Figure 1, energy management as a subset of energy planning because of the close linkages that exist between them. Policies to control demand whether by pricing or a system of incentives, the choice of modes for the transport of energy, the development of future supply sources are of as much concern to the energy manager as to the planner. Moreover, because of the inter-convertibility of energy sources, and the differences in the ease of storage and transmission of different forms, an integrated view has become essential. (For example natural gas can be used in the generation of electricity or as a feedstock for fertilizer industry; coal can be transported as electricity, or by rail or piped as a slurry, or after liquefaction or gasification). A part of the data required for an efficient management of the supply, distribution and utilization sectors is also required for energy planning, and this is shown as the feedback loop in Figure 1.

One of the first noticeable features of energy data systems in developing countries is the complete absence of data about useful parameters. But just as there are gaps in data, there are gaps in our analytical models as well. For example, there are no models that enable an analyst to reconcile individual (whether at the firm level or personal) interests with national interests.

Partly because of these gaps in data and in models, and partly because it involves a lot of assumptions about development of all other sectors, energy forecasting (or referably called estimation) is

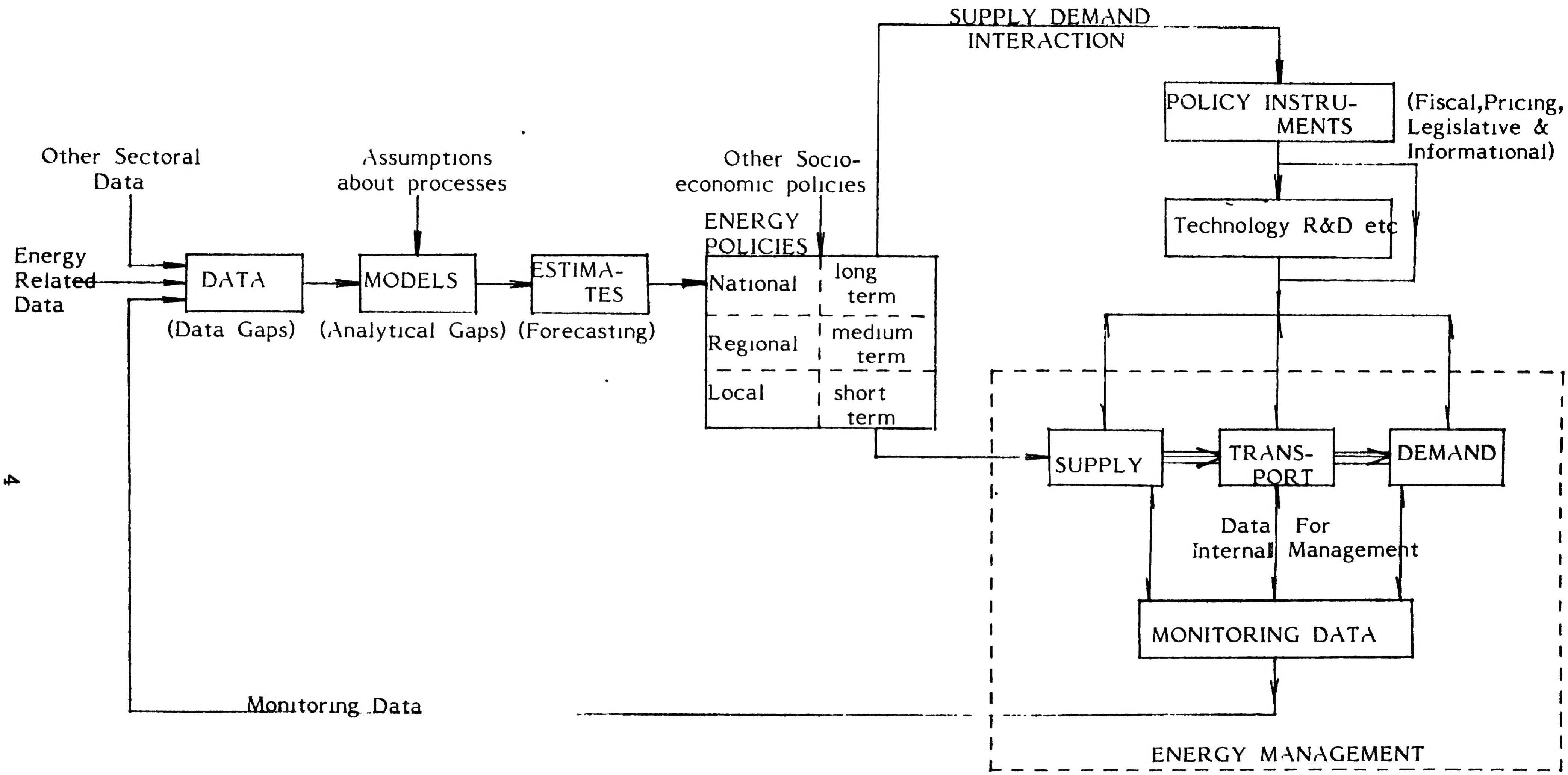

FIGURE 1: SCHEMATIC DIAGRAM SHOWING THE PRIMARY ROLE OF DATA AND MODELS IN ENERGY PLANNING AND THE SUBSUMPTION ENERGY MANAGEMENT.

an inherently difficult exercise. A number of countries have found themselves with an embarrassing amount of over capacity that was not foreseen. The list includes both developed countries like the U.S.A., U.K. and France and developing ones like Taiwan. But it is one of the central features of energy planning and must be conducted, for the development of many downstream facilities are dependent upon it. There can be no argument that efforts made to improve our techniques for estimating future supplies and demand.

As also shown in Figure 1, supply-demand interaction is an important aspect of energy planning. In this are included, pricing and incentive policies, educational and informational campaigns to control demand; investment analyses to decide on the construction of new supply sources and transport and distributing networks. Many of these policies have second-order effects, that spur the development of new technologies and processes. In demand management, the emphasis is on achieving short-term and quick changes whereas actions for increasing sources of supply are spread relatively over a longer period of time.

2. DATA BASES

The questions discussed in this section are generic to all the different energy subsectors. In fact, these questions ought to be answered before the creation of any data base. These are questions about <u>whether</u> or not data needs to be collected, <u>why</u> it should be collected, of <u>what</u> kind (i.e., what attributes must it have), <u>how</u> it should be collected, transmitted, organized, stored, retrieved and finally the institutional and locational questions of <u>who</u> and <u>where</u> also need to be answered.

2.1 <u>Costs and Benefits</u>: The cost of obtaining or collecting information must be balanced against the cost of errors in policy decisions that would be made in the absence of that information. In other words, the cost of data collelction, validation and analysis ought not to exceed the cost of errors in policy decisions that result from the lack of that information. But this principle is more easily stated than implemented (United Nations, 1983). For it is quite possible that decisions based on forecasts derived from data, either of which may be poor,, could produce much worse effects than those based on purely qualitative foundations (Watanabe, 1975). Moreover, the difficulty is compounded by the boundary problem that besets all cost-benefit analysis: i.e., the spatial, temporal, institutional and social boundaries beyond which one ignores costs and benefits. Nonetheless, a balance must be struck between the effort

expended to obtain some piece of information and the benefit to be expected from it. Sometimes, sample surveys, suffice in place of entire population censuses; and sometimes, surrogate variables may be fruitfully used, borrowed either from similar situations in other sectors or countries. To give examples, one could use time spent in gathering fuelwood in absence of data on the extent of local deforestation and it would be out of question to try and find out every household's cooking energy consumption, appropriately designed sample surveys would suffice.

Similarly, there are costs and benefits associated with electric metering. While it is possible, it is not advisable to meter every bifurcation. For large consumers of electricity it is considered essential to meter electricity by processes: thermal, motive, heating, lighting and chemical. The trend of having unmetered supply (and flat rates) at the low-tension end, however, cannot be defended on any grounds. For remote places and for small consumers, the meters could be read less often than monthly. Having unmetered supply besides adding to missing information, implies zero marginal costs and provides absolutely no incentive to conserve energy.

2.2 Attributes: A comprehensive energy data base has to be tuned to meeting as many valid requirements as possible. Given the importance of the energy sector, it is not surprising that there are multiple users and multiple uses for energy data. The users include the Planning Commission, Ministries of Energy, energy producing, distributing enterprises, research, academic and international institutions. The uses, as we have mentioned earlier, include, formulation, implementation, monitoring and assessment of plans, analysis of current and past patterns of energy production and consumption as well as forecasts of future demand and supply (ESCAP, 1982a). To this must be added investment analyses, performance evaluations and ways to influence consumption. Depending upon the application, the user, the fuel, the sector, different kinds of data are required. These, in general, will include besides energy data, a lot of other technical, financial, demographic, economic, site-specific and non-technical data.

The usefulness of any data system is a function of the timeliness or the rapidity with which data becomes available for analysis. Besides the time lag, another crucial feature is the periodicity or the frequency with which a piece of information is available. It would be expected that the periodicity required for internal management would be shorter than that required by external bodies.

The data itself must be accurate, reliable, consistent and comparable. Precision and accuracy refer to our degree of certainity about the future; reliability or authenticity about its trustworthiness; comparability to that across countries. To ensure these qualities, the People's Republic of China has introduced the Dual statistics system. Thus it should be possible to look at efficiency ratios in power plants or refineries to check whether data on input and output were realistic; '(ESCAP, 1982B). Or, one could cross-check data on coal production by data from manpower and productivity per shift data.

Needs change; users change. After 1973 there has been a shift of interest from the supply side of separate fuels to the uses to which fuels are put (United Nations, 1983). It is conceivable that two orders of magnitude reduction in the price of photovoltaics in the next decade could once again change the energy picture entirely. It is, therefore, incumbent upon the energy data system to be designed in such a way that the same data can be reclassified in many different ways so as to meet the changed requirements. Apart from the ease of reclassification, accessibility and retrievability of data are important attributes of data bases.

2.3 Organization: Though energy statistics began as independent sets of data needed for the running of particular energy producing industries (United Nations, 1983), the data required for energy planning are not a subset of the data required by the management information systems of the supply industries. Figure 1 makes this clear. A number of distortions (e.g., in pricing policies, etc.) in all countries serve to limit the focus of individual energy enterprises. It has taken years to electric utilities to take interest in conservation measures that would curtail the growth in demand for electricity. What one could affirm, however, is that a part of the management information system of the supply industries would also be useful for Energy Planning.

Currently there are numerous organizations that generate energy related statistics. These include official statistics, administrative and commercial records, research studies, etc. Data is rarely available in one place and one of the glaring areas of ignorance, even amongst energy researchers, is the knowldege of who is collecting what. (And even when this knowledge exists, the relevant information is hard to get for it is not made public). Consequently a plea is made for having a centralized energy data bank. This can be best done by organizations that use energyy data

constantly otherwise there would be a great danger of routinization and ritualization in the compliation of energy statistics which would not be responsive to changing and different needs. With the decline in computer memory storage costs, it has become obsolete to have mammoth centralized data banks (e.g., National Informatics Centre) to which everyone sends one's data for storage and tabulation with the result that even when a 'neighbouring' department wants to access data, it has to be channeled through the centralized data bank.

While there is always a tension between confidentiality of information and its widespread use and dissemination, between information required within and outside the organisation, the tendency in developing countries seems to be more to withhold information - even when there is nothing 'sensitive' about it. Researchers, and often other government officials find access to information blocked when turfs are being defended. This is as true for Brazil as it is for India. Because of the manual nature of the present data compilation techniques, much of the information that is gathered is never analysed or published.

For example, data on the causes of fatalities or injuries in Indian coal mines though collected are very difficult to extract from the voluminous paper records that exist. The widespread diffusion of small computers will no doubt help retrievability of the information that is collected. This would also help in the vertical and the downward transmission of information that must take place in any hierarchically organized data system (local to regional to central flow with different information flowing the other way).

3. <u>ENERGY SUB-SECTORS</u>:

It is a common practice, for administrative convenience, to subdivide energy ministries into departments each dealing separately with coal, oil, electric power, etc. It is realized, ofcourse, that there are strong linkages between these departments. Both coal and natural gas can be used for the generation of electricity, as feedstocks for fertilizer industry, for cooking or space heating, etc. Because of the possibilities that exist for substitution and interconvertibility amongst these different departments - including on the kinds of data that are collected. With this above qualification, we will discuss the data systems of the energy sub-sectors, with reference to the Indian situation.

3.1 <u>Oil and Natural Gas Data System</u>: Discussions of the data requirements in this sector can be sub-divided along the three major activities: exploration, refining and distribution, and consumption.

Supply forecasting is an important aspect of the exploration activities, again because a whole host of facilities must be planned in accordance with these forecasts. Our knowledge base about the oil and natural gas endowments is by its very nature probabilistic. There is insufficient appreciation, outside the oil industry, about the distinction between terms like prognostic, indicated, proven, recoverable resources and reserves.

When there is uncertainity about the very existence of a field, norm is to call it a resource, which may be sub-economic or economic depending upon the ease of extraction. A resource is upgraded to a reserve when the uncertainity is about the quantity in the field. As this uncertainity reduces, the field is moved through prognostic to indicated to proven reserve categories. The distinction between reserves in place and recoverable reserves is clear enough but other terms like possible, probable and positive reserves which are also employed and which cloud the picture. Hence, instead of the use of such adjectives and point estimates, it is far superior to quote a range of figures with a numerical degree of confidence attached to the quotes.

The physical losses in oil, during refining and distribution are kept by a number of different organizations. Similarly, data on consumption at the depot level, the data on construction costs of refineries, though available somewhere, are not readily accessible to researchers.

At the consumption end, the data base is felt to be too product-oriented and not use-oriented. It is not organized to answer questions about inter-fuel substitution or those that are important for short-term planning. For example, it is not known what is the breakdown of kerosene usage in a particular area between lighting and cooking, or of petrol consumption between 2 and 4 wheel vehicles. A governments' response to a shortage in a given area would vary with the nature of use of the substance in short supply.

As for demand forecasting, a number of different agencies in India produce a number of yearly forecasts for both individual petroleum products and the total consumption. Very little has been done to co-ordinate or reconcile these forecasts. Also, the seasonal pattern of variation in demand for petroleum products

makes it advisable that the monthly forecasts be made.

3.2 Electric Power Data System: The first impression that one has about the electric power system is that enormous amount of data are generated. These include technical, financial, commercial, administrative or managerial data. Inspite of this, the data is not adequate help to set up rational tariffs or analyse causes of power failures. As with any reporting system, there are two shortcomings: data not useful are asked for and reported, and data that may be useful are not asked for, collected or reported. The former impede management and planning and cause unnecessary data to pile up at the regional and national levels and delays in the publication of all data (e.g., the number of circuit breakers being installed by utilities is required to be reported to the Central Electricity Authority). Therefore, a thorough reassessment of what data is required at each level is required.

The inadequacies of the current methods used for load forecasting were brought out. Because electricity, on a large scale, cannot be stored, it becomes essential to forecast the diurnal variation in load in addition to the amount required. Otherwise one may be in the unhappy situation, as in Taiwan, of having to dump heat (and energy) during off-peak hours. It was also pointed out that load forecasting or estimation is basically a difficult proposition in all countries. Accurate forecasting implies a knowledge about our complex societies, that no one has. The end-use method that is employed has many shortcomings, including the short time horizons of many users and the tendency to overstate requirements in countries where power is chronically in short supply. Hence it cannot be used with any degree of confidence to forecast loads beyond 1 or 2 years. But since forecasts are required for 10 to 15 years into the future other improved methods (perhaps a combination of econometric and modified input-output) need to be developed which would also have implications for the kinds of data that will need to be collected.

One of the greatest weakness in the entire system results from inadequate or faulty metering. A large number of meters are either inoperative or defective. In a number of states in India, there is no metering of electricity to rural customers - the rates being determined by the horse-power of the pumpsets. This system of flat tariff is bad for the data system (we do not know how much is consumed, say domestically, in rural areas); is bad for economics and bad for energy conservation efforts. Since a rational price is the most effective signal for consumers, and since unmetered supply implies zero marginal costs, there is no incentive to be frugal in energy consumption. Moreover,

since losses are the difference between te energy sent out and energy sold, having unmetered supply does not allow a distinction between the energy lost in distribution, and the energy consumed (whether legally or stolen). The costs associated with the reading of meters in remote locations can be curtailed by doing this energy few months.

With the costs in India of transmission lines equalling the generating costs (about Rs. 10,000 to install an addition KW of capacity), and the losses in transmission approaching 20% *, planning transmission and distribution system has become just as important as generation planning. Also, improvements in the existing system could prove to be very cost-effective as compared to investments elsewhere. These, however, cannot be undertaken without reliable measurements.

Finally, there is the question of reliability of a power system. Currently the data system neither adequate to help analyse accurately either the causes of failures or their costs to society. Of course, the optimum target level of reliability is a trade-off between the increased system cost and the cost of interruptions in power to society. This question will assume more importance in the future when stochastic and renewable sources of power may be connected to the grid. The usefulness of digital management cannot be over-emphasized. It is certain that the costs of computerized data acquisition and transmission systems would be miniscule in comparison to either the system costs or the costs of power failures.

3.3 Industrial Energy Data Systems: 'Energy analysis' is a useful methodology to evaluate energy flows in industrial processes. It enables international comparisons of energies spent for the manufacture of a product and therefore, given a technology, the potential for energy saving can be estimated. Also existing technologies can be compared with a new technology. However, energy analysis itself requires disaggregated data on the quantities of inputs consumed, energy content of inputs, energy content of the output and the quantity of output. The existing data base (the Annual Survey of Industries) though useful for analysis at the industry level is not useful for analysis at the plant level. Moreover a few years elapse before even the industry level data get published.

One of the reasons why industries do not bother to keep a track of energy inputs the different parts manufacturing processes or products is that for many, energy costs are an insignificant proportion of the total costs. Even the information that is collected, is considered proprietary and not divulged. Inspite of the

fact there is legislation mandating reporting of energy consumption, more than 50 percent of the industries do not respond to questionnaires. The authenticity of completed responses is also in doubt. Some industries produce surreptitiously over and above their licensed capacity, hence they have to inflate their energy requirements. Again, in an era of shortages, it is feared that efficient use of energy will be penalized (by further cuts) rather than rewarded. It is crucial therefore to devise policies so that the national and the firm level objectives match - i.e., to provide incentives to make it economically worthwhile for industries to conserve energy for which they would have to collect information themselves.

While it is unrealistic to meter every energy consuming centre in a plant separately, information ought to be collected on broad application categories such as motive power, lighting, process heat (temperature spectrum), chemical use etc. Not only is such end-use information required for energy analysis and knowing which energy efficient technologies to install, it is also absolutely essential for inter-fuel substitution decisions (including those involving renewables).

3.4 <u>Coal Data System</u>: Unlike the power and oil sectors which use relatively sophisticated management techniques requiring good statistical information (ELECTROBRAS and PETROBRAS in Brazil are good examples), coal industry historically has ben a labour-intensive, small-scale (comparatively) affair that did not require much statistical information to run it. Even in the People's Republic of China, a number of small mines, producing a significant fraction of the total output, are outside government control and there is no data available on them.

In India, however, a system that collects voluminous data of dubious quality has grown around the office of the Coal Controller which was set up during World War II to ration coal amongst the major consumers i.e., the railways, steel, power and cement.

The management of the Coal Industry is such that it generates only a small range of statistics, especially about output, manpower, accidents. The rest

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Interestingly, the figures for losses are comparable in India and China.

of the statistics are produced by a large and diverse administrative machinery not necessarily concerned with the coal industry. Consequently, there are wide gaps in data. Though production is increasing and it is known that the calorific value of coal is decreasing, but not by how much. So we do not know if the energy derived from coal is increasing. Similarly, though mining conditions are constantly changing, it is not known how the depth of production is increasing, how coking properties have changed or particle sizes increased due to mechanisation, etc. The result is that it is not possible to compute production costs of mining under different conditions.

Not currently recorded is also information on how the market needs are varying, on the quality of coal that would be demanded if the consumers had a free choice. The end-use method of demand assessment used to project demand after consultations with major consumers has produced widely erring results whereas prognostications based on simple percentage bases have proved more reliable in predicting demands.

Data on the environmental impact, the health effects of the coal mining and related activities are extremely weak. Data on causes of fatality and serious injuries, though recorded, are not published. Data on effects of coal combustion are also not collected. All these need to be undertaken on a site-specific basis.

India is the only country in the world reporting energy statistics converted to coal replacement figures, whereas the international practise is to report them in coal-equivalent terms. The distinction is really between final energy consumption and useful energy consumption. The big difference between the two reporting systems comes about in the transport and domestic sectors (when both coal and diesel are used in locomotives, the coal equivalent figure will understate the amount of oil required to replace the oil. Similarly, for the household sector). But with the decline of coal consumption in steam locomotives and in households, there appears to be a case for changing over to coal-equivalent reporting units in India. However, both figures should be reported during a transition period.

In conclusion, it may be reiterated that there are enormous amount of data being generated in the coal sector. Often it is not known who is collecting what. There is no mechanism for cross-checking data and frequently one finds different figures reported for the same variable on parameter for the any one year. There is no data on flows and losses in the entire coal fuel-cycle from the extraction to utilization and disposal

stages. It is widely known that the purported amount shown on railway records is in excess of the amount actually delivered. But it is unlikely that the coal information system will improve until the management of coal industry improves.

3.5 Rural Energy Data Systems: There is a plethora of descriptors (for different energy sources) and their negatives that have found their way into common parlance but which really do not perform a good job of discriminating between the energy sources. These are opposities like conventional and non-conventional, traditional and non-traditional, commercial and non-commercial, renewable and non-renewable, existing and alternate, rural and urban, centralized and distributed, animate and inanimate, appropriate and inappropriate, etc. In the Thai statistics, for example, Charcoal when used in urban areas is classified as commercial, and when used in rual areas as non-commercial even though it may also have a commercial value there. In order to clear some of the prevailing semantic confusion, we at TERI have formed a taxonomy of energy sources based on physical principles. This is shown in Figure 2. Some of the examples of each source are given in parenthesis.

All the sources of energy currently available for harnessing can be traced to the two fundamental forces in nature - the gravitational and the nuclear. It is nuclear fusion which is the source of solar energy - the driving force for most of energy consumed on earth today. We find it useful to define the alternatives renewable and non-renewable based on storage or cycling times. These for the former are less than of the order of a hundred years (with the upper limit chosen to incorporate some afforestation programmes otherwise these times would be much less), and the limit for the latter chosen to be greater than a million years. There is such a large gap in between that it is possible to jack-knife energy sources into two categories without overlap. The depletable fuels are of course the fossil fuels and are non-renewable precisely because our rate of utilization far exceeds the rate at which they were formed.

The solar renewables can be subdivided into Direct and Indirect Solar. Sunlight could be used directly as heat, to produce electricity, or to drive a chemical reaction. Its indirect uses are when it drives other processes (mechanical or chemical) which in turn are used as sources of energy.

All energy forms are interconvertible, and this interconvertibility has not been shown in Figure 2 to keep it simple. For example, one could use, in principle, photoelectricity to drive a chemical

reaction; or wind energy to pump and store water that could be used to produce electricity when required; or solid biomass to produce (higher calorific value) liquid or gaseous fuels.

The descriptors that are functions of time (or era), space and scale are unsuited for making a classification of energy sources. These would include conventional, traditional, alternate and their antonyms. Thus wind energy may have once been traditional in Holland but now may be classified as non-conventional and nuclear which some might call conventional in France (because of scale or market share) would be non-conventional in Sri Lanka. Without a spatial and temporal context, the use of such terms ought to be eschewed.

The distinction between appropriate or inappropriate technologies needs some elaboration. One must realize that appropriateness of a technology largely depends on the method of its introduction in a particular socio-cultural milieu. Acceptance or rejection of the newly introduced technology is most often determined by the anthropological meanings attached to it by the target population, and their reactions to its impact on their social inter-relations (Amado and Blamont, 1983). For a given socio-cultural context, the appropriateness (or otherwise) of a given technology depends on how the population is introduced to the technology, whether there is an effective follow up, and the distribution of benefits resulting from the installed technology. In the People's Republic of China, for example, 30 to 40 percent of the 6 million biogas plants have become dysfunctional mainly because of the failure to impart the necessary technical operating skills to farmers. Unfortunately, in most of the current use, "inappropriateness" condemns, post-hoc, a particular technology rather than the particular methods used for its diffussion. Also very frequently submerged in such pronouncements are a number of hidden assumptions about desirable directions and rates of progress, the scales of technology, etc. that make these labels highly subjective.

The division of energy sources into commercial and non-commercial is orthogonal to what we have been discussing. The distinction is based on buying, barter and self-use. So any energy source can be commercial or non-commercial depending on whether or not it enters the "market place". By the same token, the same energy source can be commercial in place A and non-commercial in place A in the future. So there are no non-commercial sources of energy in general, a spatial and temporal fixing is again necessary.

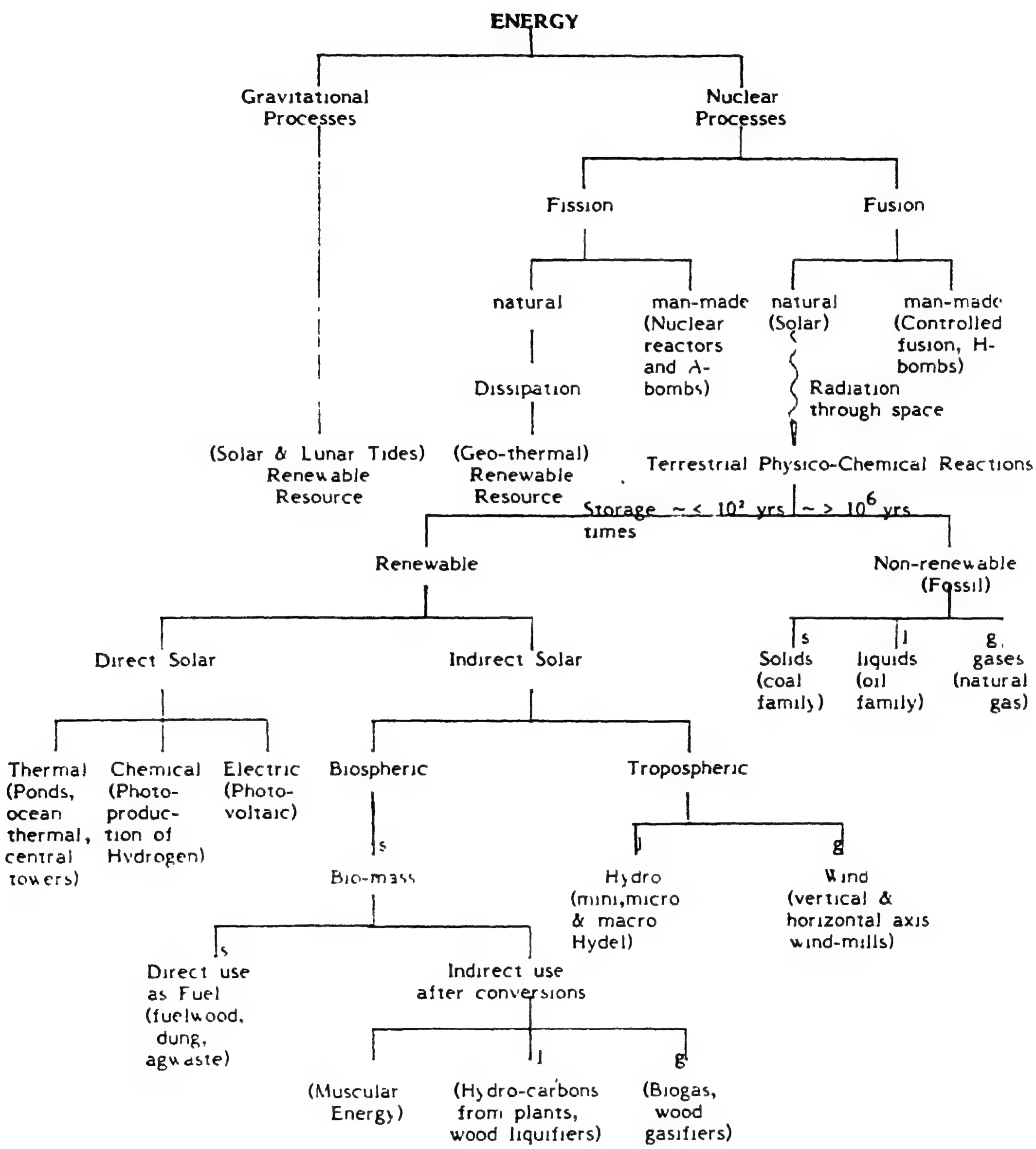

FIGURE 2 : A TAXONOMY OF ENERGY SOURCES (STOCKS AND FLOWS)
(See text for details)

Just as we have a classification of energy based on sources, it is possible to have classifications that are independent of sources but functions either of the distributing networkk (centralized vs. decentralized) or of where the end-use occurs (rural vs. urban). Though useful and convenient in certain descriptions, it must be forgotten that they say nothing about sources.

We have attempted to clarify these terms because of the conviction that woolly thinking leads to woolly recommendations.

In most developing countries, there is little information on the energy consumption and requirements in rural areas. The currently available information is not adequate to provide early warning signals of where energy scarcities are being felt and where these scarcities are acting as constraints to development or disturbing the ecological balance, etc. Information on the applications of a particular fuel are also essential to plan for substitutes, i.e., as stated earlier, one would like to know if in a particular area, kerosene is predominantly used for cooking or lighting. Then in times of kerosene shortage one would know what to provide. Information is also required by planners to know in which area a given technology, say solar pumping, would find a useful application and foretell its impact (Amado and Blamont, 1983), i.e., how one could match the needs of a region with the resources.

The paucity of information is natural, given the number of producers and consumers involved. What is known is that there are enormous cultural, ethnic, geographic, and climatic variations amongst villages. Moreover crops grown and cooking practices will differ from village to village and from household to household. This diversity ensures that there will not be a single solution to the energy problems of rural areas and that the data requirements will also be diverse.

Undoubtedly, it would be unrealistic and impractical to know and influence the energy collection and utilization behaviours of every rural household. Sample surveys need to be carried out to know the current consumption pattern. There are numerous problems with the surveys that have been carried out: problems of definition, of coverage, of measurement, of aggregation of different forms, etc. Different types of surveys are required according to the objectives. For centralized energy planning short-term (2 months) surveys of villages chosen for each agro-climatic zone might suffice whereas to ensure the acceptability of a community owned biogas plant or a solar pump, much more comprehensive location-specific surveys would be required. The survey procedures ought to be

"standardized" as far as possible so that regional comparisons could be made. The surveys would need to collect lot more information besides energy use, e.g. on cattle, land and orchard ownerships and on who has the rights to the energy assets. Therefore, in the interests of adhering to a strict 'random' design, they should not miss out on the relationships that exist.

Most of the energy used in the rural areas of developing countries is biomass based. In future these sources will be augmented by other renewables but stochastic sources like wind and 'direct solar'. For these, detailed site-specific data need to be collected on wind speed insolation etc. There is no getting away from micro-analysis. If one were to use wind data from an airport site (chosen because of being less windy) to design a windmill 200 Kms away (as it has been done) one must realize that one is not getting the optimum performance from the windmill. For solar systems one would also need data on maximum wind velocity (to anchor the system) and also on water availability.

The current policies of most governments (this is true especially of India) subsidize the capital costs of centralized transmission and distribution systems whereas the capital costs of decentralized systems based on renewable energy sources have to be borne by individual consumers. While the rational way to judge the economic viability of such systems would be on the basis of payback periods and life cycle costing and whether there is a net energy gain from them (i.e. energy obtained is greater than that spent on fabricating, transporting and installing the systems), we should not be discouraged if the current economics are marginal. (It is well known that having to pay for dung renders biogas plant uneconomical). Neither should one be discouraged if the current matching of needs, income and demand in rural areas with these technologies is poor. For energy has to be provided not only to meet basic needs but also that 20 to 25 percent of fossil fuels and hydroelectricity used today go to supply low grade heat required at less than 200^{o}C, one sees the tremendous potential for renewables. Also they provide the only hope for regions now bypassed by the current centralized production and distribution systems. It is certain that as demand grows, costs will come down.

However, subsidies are not enough to ensure the success of the application of innovative energy technology to rural areas. People do not act for economic reasons alone. Literature is full of failed attempts. It is essential to have monitoring information as to how these technologies are performing in fact. For rural energy data systems, it is not

enough for the data to flow the other way on the characteristics of new technologies, means of financing them, the risks in terms of reference readily understood. Only then can the success of such interventions be made more probable.

4. Conclusion:

In a paper of this size, it is not possible to go into great detail of every one of the issuues, dealing with energy statistics, but we have mentioned most of the relevant concerns. It should be obvious even from a cursory foray into the subject that energy statistics cover an extremely wide canvas and that most developing countries are only now beginning to grope with the issues involved. However, many countries over the last three decades have evolved fairly good data systems in the food and agricultural sector and involving demographic information for the conduct of elections. So it should also be possible to set up useful energy information systems as well. There is one caveat, however: given the enormous variety of needs and applications, it is unlikely that a single system will be capable of meeting; all the varied needs. It is not necessary however to have one large centralized information system. With the increasing diffusion of micro computers, it would suffice that many such centres have compatible formats for data storage and retrieval, so that exchanges are facilitated. For the present what is urgently required though is the compilation of a national index on the collection and availability of all the energy related data giving coverage, periodicity and source. There is an appalling lack of information about what data are being collected and where are they available. Such an index would be of tremendous help to both planners and researchers alike.

In conclusion, we reiterate that while bad decisions in the energy sector can do lasting and not easily reversible damage to the economy good decisions cannot be made without timely and reliable data.

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